

Where Is the Future in Public Health?

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Context: Today's societies have far-reaching impacts on future conditions for health. Against this backdrop, this article explores how the future is represented in contemporary public health, examining both its conceptual base and influential approaches through which evidence is generated for policy.

Methods: Mission statements and official reviews provide insight into how the future is represented in public health's conceptual and ethical foundations. For its research practices, the article takes examples from epidemiological, intervention, and economic research, selecting risk-factor epidemiology, randomized controlled trials, and economic evaluation as exemplars.

Findings: Concepts and ethics suggest that public health research and policy will be concerned with protecting both today's and tomorrow's populations from conditions that threaten their health. But rather than facilitating sustained engagement with future conditions and future health, exemplary approaches to gathering evidence focus on today's population. Thus, risk-factor epidemiology pinpoints risks in temporal proximity to the individual; controlled trials track short-term effects of interventions on the participants' health; and economic evaluations weigh policies according to their value to the current population. While their orientation to the present and near future aligns well with the compressed timescales for policy delivery on which democratic governments tend to work, it makes it difficult for the public health community to direct attention to conditions for future health.

Conclusions: This article points to the need for research perspectives and practices that, consistent with public health's conceptual and ethical foundations, represent the interests of both tomorrow's and today's populations.

Keywords: Public health, environment, climate change, future.

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MODERN SOCIETIES HAVE WIDE-RANGING IMPACTS—for example, through work environments, urban development, transport systems, and food production—on the health of people living today. But they also will have far-reaching effects on tomorrow's populations, which suggests that the future should be central to the mission and methods of public health. This article considers, first, the conceptual and ethical base of public health and, second, the “gold standard” practices through which evidence is generated for policy.

The first section examines the concepts and principles underpinning public health. It notes the unanimous view that the concept of public health is inherently oriented toward the future. That is, scientific and professional bodies concur that public health is about taking action today to protect and promote health tomorrow. Its ethical base, including its adherence to the principle of stewardship, similarly suggests that public health operates with extended timescales, with its sights set firmly on sustaining the conditions for health long into the future. On both conceptual and ethical grounds, there is reason to assume that future as well as current populations are included in “the public” that the public health research and policy communities seek to serve.

The second section turns from overarching principles to evidence-gathering practices. To make this task manageable, I consider three core fields of public health research: epidemiological research, intervention research, and economic research. Within each, I select an approach that has achieved paradigmatic status, discussing risk-factor epidemiology, randomized controlled trials (RCTs), and economic evaluation, respectively. An examination of these three exemplars suggests that public health research is set within narrow temporal horizons. In each, the focus is on the near future rather the longer term, with the health of individuals alive today taking precedence over the well-being of generations to come.

The article therefore points to a tension at the heart of the public health enterprise. Its mission is centrally engaged with the future. Its methods for gathering evidence lock it into the present, while beyond this narrow time horizon lie the daunting public health challenges that our generation will leave for future generations, not only for our children, but also for the children and grandchildren that our children have.

A Future-Facing Public Health?

The classic definition of public health was articulated nearly a century ago by Charles Winslow, a professor of public health at Yale University. Using the term *efficiency* to encompass what today would be called *functional health*, he stated that “public health is the science and art of preventing disease, prolonging life, and promoting physical health and efficiency through organized community efforts” (Winslow 1920, 30). Winslow’s concept of public health has been endorsed by the public health community and adopted in an abbreviated form in official reports (Acheson 1988; Ministry of Health Services 2005; Nuffield Council 2007; Wellcome Trust 2004) and by training agencies and professional associations (e.g., CAMP 2009; FPH 2009; PHRU 2008; UKPHA 2009). All agree that public health is “the science and art of preventing disease, prolonging life and promoting health through organized efforts of society.”

Two features of this widely held view of public health should be underscored. First, preventing, prolonging, and promoting are future-oriented activities; they turn on the organized efforts of societies now to secure health gains in the future. In contrast to the wider health care system, the primary concern is not identifying and repairing health problems resulting from past exposures. Instead, it is identifying and addressing risks to future health.

Second, this concern with warding off threats to health brings with it an emphasis on societal action, on what Winslow called “organized community efforts” (1920, 30) and what today are referred to as “collective or social actions” (Last 2001, 145). As the U.S. Institute of Medicine put it, “Public health is what we, as a society, do collectively to assure the conditions in which people can be healthy” (IOM 1988, 1). Public health’s mission is therefore to “fulfill society’s interest in assuring” these conditions (IOM 2002, 411). The conditions for health are increasingly referred to as *social determinants*. The recent World Health Organization (WHO) commission explained that these determinants encompass “the conditions in which people are born, grow, live, work and age” and “deeper structural conditions that together fashion the way societies are organized” (WHO 2008, 26). Social determinants therefore include both people’s everyday environments and the societal structures and policies that shape them.

Public health's future orientation and societal reach have strong ethical foundations. At its heart is the principle of moral equality, the principle that everyone matters and no one individual is intrinsically superior to, or worth more than, another. Public health is not exceptional in its adherence to the principle, for it is a core social value, enshrined, for example, in the U.S. Declaration of Independence and the UN Universal Declaration of Human Rights (Kymlicka 2002). Tasked with securing the conditions for everyone's health, public health is inevitably aligned with government and the state. While all sectors of society—families and communities, industry, voluntary organizations, public services—affect these conditions, the responsibility for public health ultimately lies with governments. Their obligations are captured in another core principle of public health, that of stewardship. A recent British review noted that “the concept of stewardship is intended to convey that liberal states have a duty to look after important needs of people individually and collectively. The state has a responsibility to provide the conditions under which people can live healthy lives” (Nuffield Council 2007, v). In a similar vein, a major U.S. review of public health emphasized that “the fundamental duty of government . . . is to support a healthy future for the American people” (IOM 2002, 1). While expressed here in terms of the nation-state, the principle of stewardship also has a global dimension. With actions in one country able to affect health conditions everywhere, stewardship is increasingly seen to place a duty on governments not to act in ways that would damage the health of those living outside their national borders (UN 1987; World Bank 2010).

What remains implicit in the concept and ethical base of public health is the generational status of the people who are its focus. Winslow's definition does not specify whose future life is being prolonged; similarly, the Institute of Medicine's mission for public health and the Nuffield Council's deliberations on stewardship do not indicate which people should be assured of the conditions to be healthy.

Traditionally, public health has been concerned with ensuring the conditions and promoting the health of those currently living. Thus in the late nineteenth century, the sanitary movement in Britain was concerned with preventing disease and prolonging life in its rapidly expanding urban population. Although investment in clean water and sewage disposal benefited subsequent generations, this was a secondary benefit rather than the primary aim (Hamlin 1998). As the twentieth century progressed and life expectancy rose in high-income societies,

it was the challenge of chronic disease and an aging population that preoccupied public health scientists and policymakers (Susser 1985). The time frames of public health correspondingly lengthened, with more attention given to prevention in middle-aged and older persons (Kuh and Davey Smith 1993). In recent decades, evidence of the long-term effects of conditions in early life on future health trajectories has widened time frames still further (Kuh and Ben-Shlomo 2004). Longitudinal studies are now documenting how children's future health is influenced by the conditions in which their grandparents lived and their parents were born (Modin and Fritzell 2009). Projected forward in time, this suggests that the conditions for the health of today's population will also affect the health of their children and their children's children.

Public health research and policy are being urged to extend the concept of "the public" to include generations located further ahead in time. The reason is the increasing temporal reach of "what we, as a society, do." Preindustrial societies, with their limited technologies and low fossil-fuel consumption, had little environmental impact, and their economies and lifestyles did not fundamentally alter the conditions for health either in other societies or for future generations. With the advance of industrialization and technology, however, the imprint of the present on the future deepened. As a result, today's economies have extensive and long-lasting effects on the world's physical and biological systems. Recent reports document how economic growth and rising living standards have been sustained at the cost of ecological stress: deforestation and ocean acidification, soil degradation and loss of biodiversity, as well as widespread environmental pollution from the extraction of minerals and fossil fuels (Adam 1998; Confalonieri and McMichael 2008; SCBD 2009; UN 1987). These reports make clear that today's societies are—literally—changing the future; they are irreversibly shaping the environments on which the survival of future generations depends. The common message is that the adverse effects of "today's ongoing, and generally escalating, human-induced changes in the Earth System . . . extend into future decades and are likely to increase if environmental conditions further deteriorate" (Confalonieri and McMichael 2008, 5).

The most dramatic example of how future conditions for health are set by the societies of today is, of course, anthropogenic climate change. Emissions of CO₂, the major greenhouse gas, are continuing to accelerate (Raupach et al. 2007), resulting in atmospheric concentrations that now far exceed preindustrial levels (IPCC 2007, 72). Indeed, even if

greenhouse gas concentrations were stabilized today, global warming and the rise in sea level would continue “for centuries due to the time scales associated with climate processes and feedbacks” (IPCC 2007, 46).

The ethical issues raised by anthropogenic changes in people’s conditions for health are being recognized. It is clear that these changes are already having profoundly unequal effects, that is, disproportionately affecting the well-being of poorer populations who have contributed least to them (Costello et al. 2009; World Bank 2010). Such evidence is strengthening the case for health equity to be written into the environmental agenda, with climate stabilization and environmental stewardship regarded as preconditions for reducing health inequalities within and between countries (Costello et al. 2009; Friel et al. 2008; WHO 2008).

The ethical issues raised by ecosystem changes extend beyond their unequal impacts on groups living at the same time, and the greater inequality will be intergenerational. Future ecosystems and future populations, and therefore future health, are most at risk. Estimating these risks presents major research challenges (IPCC 2007; WHO 2009b). Uncertainty is endemic, with respect both to environmental and climate sensitivity to past and present human activity and to the impact of remediation and mitigation policies. It is evident, though, that while “climate change will have serious impacts within the lifetime of most of those alive today,” these impacts will intensify over time and worsen with each succeeding generation (Stern et al. 2006, 23). As this implies, today’s populations are “the privileged minority,” and the disadvantaged majority are those yet to be born (Mulgan 2006, 229). Nearly thirty years ago, Sen described the depletion and degradation of the world’s natural resources as “a kind of calculable oppression of the future generation” (Sen 1982, 346). In a similar vein, the *Brundtland Commission* on the environment noted that “we borrow environmental capital from future generations with no intention or prospect of repaying [it]” (UN 1987, 8). Today’s reports make it even clearer that the earth’s capacity to sustain future life is being permanently impaired by the way its ecosystems are being exploited by today’s populations (Braat and Brink 2008; Confalonieri and McMichael 2008; Costello et al. 2009; World Bank 2010).

As this suggests, we urgently need perspectives that explicitly incorporate future generations, making future publics and future health integral to the concept of public health. The foundations for such an approach

are already in place. In its original and modified forms, Winslow's definition does not limit the temporal frame of reference, and as he observed, "Constant attention is required to maintain the environment in a healthful condition" (Winslow 1920, 24). Public health's mission to ensure the conditions for people to be healthy similarly does not stipulate a time frame; few would argue that it ends with the deaths of those living today. Similarly, few would deny that the government's fundamental duty to support healthy futures extends to those who are yet to be born. Future generations, including today's children, have no political voice to argue for policies to ensure their conditions for health. Lacking direct representation, they rely on governments, and the public health community in particular, to advocate on their behalf.

The principle of moral equality provides strong ethical grounds for doing so; if everyone matters, and matters equally, "people should not be treated differently because of their different locations in time" (Pearce et al. 2003, 122). Across the sciences and the humanities, authoritative voices make clear that today's adults should not be privileged over tomorrow's children (Adam and Groves 2007; Mulgan 2006; Sen 1982; Stern et al. 2006). Moral equality makes intergenerational equity integral to stewardship, imposing obligations on governments to "conserve and use the environment and natural resources for the benefit of present and future generations" (UN 1987, 348). This duty of care is captured in the concept of sustainability. Sustainability requires governments to discharge their stewardship responsibilities in a way that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (UN 1987, 43). We could argue that, set in this context, the conditions for health over time are an index of how successfully public health is fulfilling its mission and discharging its responsibilities to society.

A Present-Focused Public Health?

The preceding analysis suggests that public health is distinguished by its future orientation. We would therefore expect public health research to be forward thinking, focused on protecting the conditions for health for both today's and tomorrow's populations. Accordingly, we might expect the "gold standards" in public health research to be set by approaches capable of capturing, and informing action on, emerging threats to health.

This, however, does not appear to be the case. Instead, major fields of research are generating evidence using perspectives and practices that do not facilitate a sustained engagement with the future. Here I consider three of these fields—epidemiological, intervention, and economic research—and, for each, select an influential approach. While these approaches represent only part of a much wider spectrum of research, each sets the standards for what is regarded as “best practice” in its field (Edejer et al. 2003; Susser 1985; Thorax 2004). Consequently, each provides evidence regarded as scientifically robust by both the research and the policy community.

The epidemiological example is risk-factor epidemiology, a subfield of the discipline that developed in high-income countries in the second half of the twentieth century in response to the etiological challenges presented by the epidemics of chronic disease (Kuh and Davey Smith 1993; Susser 1985). Through the elucidation of the behavioral factors (e.g., cigarette smoking, sedentary lifestyles) and their physiological mediators (obesity, high blood pressure) contributing to chronic disease, risk-factor epidemiology rapidly became “the new paradigm” in public health research (Susser 1985, 150). Its achievement has been to identify the proximal causes of mortality, those factors in temporal and spatial proximity to the individual whose health is damaged by them. The paradigm also helps quantify this health damage. As an illustration, the WHO’s report on risks to global health was able to conclude that “the leading global risks for mortality in the world are high blood pressure, tobacco use, high blood glucose, physical inactivity, and overweight and obesity” (WHO 2009a, v). This is a message easily translated into policy. As the report notes, “By quantifying the impact of risk factors on diseases, evidence-based choices can be made about the most effective interventions” (WHO 2009a, 1).

But the risk-factor perspective has important downsides. Searching for causes at the individual level assumes that little is happening in the wider environment of etiological significance for population health (Pearce 1996). Specifically, its assumption of stability in the wider environment means that the paradigm “is too narrow to cope with a future that is already bearing down upon us” (Susser 1998, 609). As Anthony McMichael contends, the risk-factor perspective’s restricted spatial and temporal reach makes risk-factor epidemiology particularly ill suited to the twenty-first century, in which the major threats to the health of current and future generations lie in

changes occurring in societies and in the wider ecosystem (McMichael 1999).

The second example is from the field of intervention research. Here, the benchmark for assessing effectiveness is set by randomized controlled trials (Thorax 2004). In practice, public health researchers rely more on quasi-experimental designs without the random allocation of study participants to the intervention or control arm (Petticrew and Roberts 2006). Together, experimental and quasi-experimental approaches have transformed the evaluation of public health interventions, enabling systematic reviews of trial findings to assume a preeminent position in the public health evidence base (Thorax 2004). Like risk-factor epidemiology, trial methodologies seek to limit uncertainty about causality by focusing on exposures that lie close, both temporally and spatially, to the outcome of interest. They enable researchers to capture the effect of an intervention on the individuals exposed to it, with the magnitude of the effect estimated by comparing outcomes in the exposed group with those in a non-exposed control group.

As this description indicates, trial methodology has important design requirements. Whether an experimental or quasi-experimental approach is adopted, changes in exposure and outcome need to be amenable to precise measurement for a defined population. Data from the same individuals are therefore preferred, with post-intervention changes in outcomes tracked across relatively short periods of time. For example, in two recent reviews (of workplace smoking restrictions and the health effects of workplace changes), more than 80 percent of studies had follow-up periods of twelve months or less (Bambra et al. 2008; Fayter et al. 2008). As this suggests, the trial design works best for individual-level outcomes that respond quickly to changes in individual-level exposures in stable populations whose health is not threatened by wider environmental changes.

The scientific status accorded to evidence derived from randomized controlled trials, and from trials more generally, inevitably produces a bias against investigating risks to health that fall beyond their reach. These include environmental changes affecting whole populations (Pearce 1996), as well as health risks from current policies and interventions incurred not by the exposed population but by future populations. For public health in the twenty-first century, it is the future health risks posed by today's rapid social and environmental changes that urgently require the attention of researchers and policymakers.

The third example is economic evaluation, the method that defines economic approaches to public health. It encompasses a range of techniques, including cost-benefit analysis and cost-effectiveness analysis. In broad terms, these kinds of analyses provide a way of comparing inputs and outputs (e.g., money spent and health gained) over time for different policy options. Their aim is therefore to inform governments' decision making (Pinkerton et al. 2002). And because this aim has been fulfilled, economic evaluation has increasingly become the policy tool of choice (Edejer et al. 2003; Hjelmgren, Berggren, and Andersson 2001).

In principle, economic evaluation enables conditions for future health to be brought into governments' policy calculus today. But policies and interventions are typically evaluated from the perspective of the current generation, and future costs and benefits are therefore assessed according to their value to people now, looking forward in time, rather than to those whose lives will be affected in the future. In economic parlance, future costs and benefits are "discounted": the value of both costs and benefits is progressively scaled down as temporal distance from the present lengthens. The WHO's guide to cost-effectiveness analysis describes the reasoning as follows: "Discounting is the process of converting future values—e.g., costs or health effects—to their present values to reflect the belief that, in general, society prefers to receive benefits sooner rather than later, and pay costs later rather than sooner" (Edejer et al. 2003, 67). A review of policy guidelines in Europe, North America, and Australia found that standard discount rates between 3 and 5 percent are widely employed (Hjelmgren, Berggren, and Andersson 2001). In concrete terms, this means that a policy bringing short-term benefits but imposing heavy long-term costs will be more positively rated than one with upfront costs and deferred benefits. The former category would include economic policies that improve health at minimum cost for the current generation by imposing environmental and health penalties on subsequent generations. The latter category would include policies to contain and mitigate environmental degradation.

The standard economic approach to time and, particularly, the intergenerational inequity of a metric that weighs the interests of the present population above those of future populations, has been roundly criticized (Adam and Groves 2007; Broome 1994; Mulgan 2006; Sen 1982). Building on this criticism, the United Kingdom's official report on the economics of climate change questioned its capacity to deliver sound policies (Stern et al. 2006). The report expressed deep concerns

about governments' use of discounting to manage threatened natural resources. As it noted, a practice that seeks to minimize short-term costs and maximize short-term benefits increases the risk of delaying interventions beyond the point at which dangerous climate change could be prevented. In a departure from economic convention, the report asserted that the principle of moral equality requires that future generations have "the same claim to our ethical attention as the current one" (Stern et al. 2006, 31). It therefore argued for a near-zero discount rate, with the welfare of future generations treated "on a par with our own" (Stern et al. 2006, 31).

Risk-factor epidemiology, trial methodology, and the standard approach to economic evaluation are closely aligned. Through their complementary approaches, they can tease out proximal threats to the health of individuals and determine what works to limit them—with evidence from these observational and experimental studies providing data from which the parameters of economic models can be estimated. Both separately and together, their orientation to immediate risks and short-term benefits has made a major contribution to public health research.

The orientation of these three approaches informs and legitimates interventions directed at individuals rather than populations and at lifestyles rather than environments, a focus that has dominated public health policy for most of the last century (Nathanson 2007). This individualistic focus has been particularly in evidence since the 1970s (Graham 2009; McKinlay 1975), decades in which the doctrine of economic liberalism exerted an increasing influence on domestic and global policy (Glyn 2006). The doctrine downplays social solidarity and abhors state regulation; instead, its vision is enabling self-interested individuals to maximize their personal gain in free-market economies. It therefore is not surprising that, in his review of public health policy in North America, Fox notes that tackling wider determinants can command little public support, leaving governments reluctant to invest scarce resources in securing diffuse and long-term health benefits (Fox 2006).

This concentration on immediate risks and short-term benefits is not only in step with the political discourse of recent decades; it also meshes well with the short electoral cycles in which democratic societies operate. Typically no longer than five years, policy timelines tend to be correspondingly compressed. Time-limited mandates mean that governments often prefer policy goals capable of achievement—or at least demonstrable progress—within their period of office. With the

emphasis on “early deliverables” and “quick wins,” more intractable challenges—for which progress is uncertain and potential benefits are long term—tend to be sidelined (Adam and Groves 2007). The tendency toward “short termism” has been reinforced by management practices introduced into public health, and into the health sector more generally, in recent decades. Designed to improve efficiency, these practices combine centrally determined standards with inspection regimes to check on the performance of organizations, teams, and individuals. The approach has been particularly enthusiastically adopted in England (DH 2004). According to its critics, the result is a workforce investing its limited resources in meeting short-term targets rather than addressing the longer-term challenges facing public health (Graham 2009; Hunter and Marks 2005).

Future-Proofing Public Health

In this article, I have sought to answer the question, Where is the future in public health? My search began with the conceptual foundations of public health. Here, I found the future to be central: the duty to protect and promote the conditions for a healthy future is not time limited but is open ended. Grounded in the principles of moral equality and environmental stewardship, this future orientation puts intergenerational equity at the heart of public health’s mission. The principles require the research and policy communities to serve, with and through governments, as trustees of the conditions for health for present and future generations.

A different answer to the question emerged when I turned to approaches to evidence-gathering in public health. I found that three influential examples shortened the causal chains between exposure and outcome, both spatially and temporally. Risk-factor epidemiology and controlled trials facilitated the production of knowledge about the health impact of individual-level factors and changes in these factors over the short term. Standard economic evaluation quantifies the resulting health gains through metrics that attach greater value to the current population than to the future population.

These mainstream research practices sit comfortably alongside the individualistic orientation of contemporary health policy and the wider doctrines of economic liberalism that have driven national and global

policy over the last thirty years. They fit well, too, with the compressed timescales for policy delivery, in which governments typically have a limited period to demonstrate progress on the programs on which they were voted into power. Contemporary politics, like contemporary public health, seems to have an inbuilt bias against the future and the people who will inhabit it.

Such a bias would be less problematic if societies had only limited spatial and temporal impacts on the conditions for health. Stability in these conditions could then be assumed, and evidence gathered by public health researchers on the near range and short term could enable governments to claim that they were promoting a healthy future for both today's and tomorrow's populations. The defining feature of advanced and developing economies, however, is their capacity to irrevocably change future environments, and to do so for the worse (Adam 1998; Costello et al. 2009; Stern et al. 2006; UN 1987).

Consequently, a disjunction between principles and practices in public health research matters: between a conceptual engagement with the future and an empirical bias against it. As I have indicated, the social determinants of health have their most powerful effects on future generations, and what the WHO refers to as "the conditions that together fashion how society is organized" (2008, 26) will have their greatest impacts not on today's adults and children but on those yet to be born. We therefore need approaches to public health research and policy that represent the interests of future generations. These generations include all those born from today. As Marc Davidson pointed out, "The first members of future generations will be born tomorrow, while in a hundred years' time almost everyone will belong to future generations from today's perspective" (Davidson 2006, 56).

Developing a blueprint for a future-oriented public health is a formidable research challenge, made all the more difficult because other disciplines do not have handy prototypes. They, too, are seen as biased against the future and inadequately equipped to capture societies' accelerating impacts on the conditions for survival (Adam and Groves 2007; Heinzerling and Ackerman 2007). I offer here some possible ways forward. First I briefly discuss how future generations might view current approaches to gathering evidence before considering alternative ways of generating public health evidence.

With respect to the three exemplar approaches, future generations are likely to challenge risk-factor epidemiology's influence on public

health policy. They would probably prefer approaches that identify the degradation of the environment, rather than increases in risky behaviors, as constituting the major global threat to health. They may be drawn to branches of epidemiology that focus on how past and current conditions “cast long shadows” over both future conditions and future health. Such an approach is exemplified by life course perspectives with their rich insights into how the health of future generations may be compromised by deteriorating conditions in the generations that preceded them. The policy messages from this approach have resonance for societies experiencing rapid environmental change. Life course perspectives make clear that missed opportunities to remedy threats to health at critical points can be hard, if not impossible, to remedy later (Halfon and Hochstein 2002).

Future generations are likely to show little interest in intervention studies designed to measure short-term health effects resulting from modest changes in proximal exposures. They would probably argue that their health will be much more affected by changes of a magnitude and scale difficult to capture through either trials or natural policy experiments. While recognizing the uncertainties involved, future generations would give priority to the scenario-based models advocated by McMichael (1999) and Adam and Groves (2007) to chart the long-range environmental impacts of current national and global policy. We could assume, too, that they would want to assess the future consequences of weak policy responses: of political inaction, delayed action, and piecemeal action (Braat and Brink 2008; WHO 2009b).

With respect to economic evaluation, future generations would no doubt point to inconsistencies in the treatment of time (Prager and Shertzer 2006). On the one hand, governments are adopting policies to promote sustainability, policies that eschew the standard economic approach to discounting. For example, rather than privileging the interests of current generations, national policies and international conventions on biodiversity and climate change seek to conserve finite and fragile environmental resources for the benefit of future generations. On the other hand, mainstream evaluations in public health employ discount rates that weigh benefits to the current generation above those to future generations, and thus support the unsustainable use of natural resources. To resolve this inconsistency, future generations would almost certainly insist that economic models take greater account of the interests of those yet to be born, by adopting intergenerational approaches to

discounting (Sumaila and Walters 2005). In particular, they may well argue that the approach to discount rates adopted by the *Stern Review* for climate change should be adopted as the standard for public health policies more generally. In other words, all policies with an impact on future conditions for health should be evaluated using near-zero discount rates.

Adapting the existing approaches—whether the three considered here or others—is unlikely to satisfy future generations. Critics have noted that science as a whole rests on assumptions that, in a world in the grip of changes set in train by human activity, no longer hold (Adam and Groves 2007; Funtowicz and Ravetz 1993). Thus we can no longer assume that the environment and climate systems are stable, that change is local and measurable, that effects are predictable and short term, and that uncertainty can be controlled through research designs and statistical methods. Today, research is being undertaken in the context of disruptions to the earth's ecosystem which are triggering dangerous, variable, and non-linear changes in the conditions for health. When “facts are uncertain, values in dispute, stakes high and decisions urgent,” a new scientific paradigm is needed (Funtowicz and Ravetz 1993, 744). Funtowicz and Ravetz coined the term *post-normal science* for this paradigm, a designation that distinguishes it from science as it is normally practiced (Funtowicz and Ravetz 1993, 2008).

The hallmark of post-normal science is its approach to uncertainty, risk, and values. Rather than uncertainty being a reason for delay, it is seen as the reason to act. This is because uncertainty is systemic and brings with it the risk of consequences that can be catastrophic (Campbell-Lendrum et al. 2009; WHO 2009b). Even when the probability of such consequences is low, the environmental and human costs of underestimating them are much greater than the dangers of overestimating them. “The more uncertain we are about outcomes, the more certain we should be about the need to take action now” (Quiggin 2008, 209). Post-normal science also diverges from conventional science by explicitly rejecting value neutrality, arguing instead that all those affected are “legitimate participants” in steering the research agenda and in ensuring the quality of its outputs (Funtowicz and Ravetz 1993, 752). But while future conditions matter most to future generations, they obviously are unable to exercise their participatory rights. Stakeholder forums therefore must include “representatives whose remit and responsibility is the long-term future” (Adam 2009, 13).

While post-normal science is still evolving, its approach to the future—to the conditions that will determine the health of future populations—is consistent with the principles that have long underpinned public health. A paradigm shift may well be in progress, one that enables public health to make the promotion and protection of healthy futures central both to its mission and to its research practices.

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Acknowledgments: The catalyst for this paper was Tim Mulgan's book *Future People*. I would also like to thank *The Milbank Quarterly* reviewers and editor for their helpful comments and Sally Stephenson, University of York, for her assistance with the references.